Name:
Date:

Density Lab

Significant Figures

In performing scientific experiments, one makes many measurements to varying levels of precision. To express the precision of a measurement, scientists use significant figures. To ensure accurate reporting of data and results, the correct use of significant figures is essential. As a general rule, significant figures are all of the certain digits from a measurement plus the first uncertain digit. Here are two examples:

Example 1. A student makes a measurement with the lab scale that reads 6.12 g. The scale reads digits to 1/100 of a gram. In making the measurement, the student notices that the last digit varies a bit while the object is on the scale, showing now 0, now 3, now 2. This shows that the last digit is the least reliable digit and no further significant figures can be used than this last one, even in calculations made with this number.

Example 2. The instructor is measuring out liquid reagents for this evening's lab. He pours the substance from a bottle into a graduated cylinder. The cylinder has gradations that show a mark for every milliliter (mL). The instructor wishes to measure out exactly 6.15 mL of the liquid. By judging when the level of the liquid is half-way between the 6.1 mL mark and the 6.2 mL mark, he can roughly estimate when he has the desired amount of liquid. The last digit in his measurement is the uncertain one.

Rule: There are some simple rules that govern the determination and use of significant figures (s.f.):

1. The digits 1 through 9 are always significant.
2. Zeros are significant under two conditions: a., when they are between two non-zero digits or b., when they follow non-zero digits of significant zero digits **and** are to the right of the decimal point.

Example 3. A measurement resulting in the number 567 g has three significant figures. Measurements of 567.1 g and 567.0 g have 4 significant figures and measurements of 567.05 g and 567.50 g have five significant figures each.

Three S.F.	Four S.F.	Five S.F.
403 g	403.0 g	403.01 g
40.3 g	40.30 g	40.301 g
4.30 g	0.4300 g	4.0030 g
0.403 g	4.003 g	0.40003 g

The following numbers might appear to have more significant figures, but each has only three: 4030 g, 40,300 g, 403,000 g.

For the following, indicate the number of significant figures using the above rules:

1) 50.0 g ___	4) .0004 mL ___	7) 1,000,001 g ___
2) 40. mg ___	5) 0.3004 g ___	8) 5,678.21 mL ___
3) 0.40 L ___	6) 3,000 g ___	9) 20.4070 g ___

Significant Figures and Calculations

When you do calculations with the numbers you find in collecting experimental data, you must preserve the precision of the original measurements. There are two rules governing the calculation of significant figures: one for addition/subtraction and one for multiplication/division.

Rule: For addition and subtraction the rule is that the answer should have the same number of decimal places as the measurement having the least number of decimal places.

Example 4.

3.982 g	3.982 g
17.12 g	17.12 g
+ 983.3 g	+ 983 g
1004.4 g	1004 g

Calculate the following using the rule for addition and subtraction for significant figures:

1) 42 g + 37 g + 1.1 g + 0.88 g + .99 g = _____

2) 33 mL - 1.3305 mL = _____

3) 2.0 x 10^{2} g + 30. x 10^{3} g = _____

4) 1.26 x 10^{-3} + 2.4 x 10^{0} = _____

Rule: For multiplication and division, the number of significant figures in the answer should equal the number of figures in the least precise component.

Example 5.

4.28 mm x 8.789 mm/.85 mm = 44 mm

Calculate the following using the rule for multiplication and division for significant figures:

1) 4.00 L / 1.000 L = _____

2) 42 g x 1.01 mL/g = _____

3) (92 mL)(491 mL)/4.321 mL = _____

4) 2(.008 in)(6.6722 in) = _____

Things to remember:

First, calculators can exaggerate the precision of a calculation by giving far more digits than are warranted by the number of significant figures in the original numbers. Don't write down all the digits shown on a calculator! Figure out how many digits you should have and round up if the number after the last significant digit is 5 or above or leave the number as it is if the number is 4 or below. Second, if you are doing a complex calculation with two or more steps or operations, do operations in parentheses first, figure out those significant figures and apply that to the next calculation.

Rule: Numbers that are not the result of a measurement are often *exact* numbers. These may be conversion factors, standard values (such as π) or given constants. Exact numbers **do not** affect the number of significant figures.

Density Experiment

Always use ink when recording experimental data. Also, do not scratch out mistakes completely: simply cross them out with a neat line and write the correction. Record data as soon as you obtain it, don't depend on your memory! Always record measurements with the correct number of significant figures and *always* write down the units!

Density of a Solid

Procedure:

1) Obtain a solid material from the instructor and record its identification

2) Weigh the material to the nearest 0.01 g (to the maximum precision offered by the scale)

3) Select a graduated cylinder into which the material will fit and partially fill it with water. Estimate the reading of the cylinder to one more significant figure than the smallest marked division and record it.

4) Gently slide the material into the partially filled cylinder. Read and record the new level. This allows you to determine the volume of the material.

5) In the space provided, calculate the density of the material using the equation provided. Show units on all parts of the calculation and use the factor-label method. This will be the *result* of the lab.

Density of a Liquid

Procedure

1) Obtain a small flask containing 30 mL to 40 mL of the unknown solution. Record the information on its label.

2) Obtain and clean a 10 mL graduated cylinder. Use soap and a brush until the water 'sheets'. Rinse it thoroughly with water, then with the solution. Use only a small amount of solution and dump out the excess after rinsing and before putting any solution in the cylinder to measure it.

3) Weigh the graduated cylinder before you fill it with solution. Record this value since it will allow you to find the mass of the solution later.

4) Put 5 or 6 mL of the solution in the cylinder and record the volume to the correct number of significant figures.

5) Weigh the cylinder before adding any more solution and record this information with the data regarding its volume.

6) Add about 1 mL to the cylinder and record the volume as precisely as possible. Weigh it again. Record both of these data points.

7) Repeat step 6) until you have performed at least 5 trials and your final volume is around 9 mL.

Calculations

Procedure

1) Compute the mass of each trial of solution by subtracting the mass of the graduated cylinder from the number you recorded.

2) Divide each mass by the volume for that trial to find the density. You only need to show one calculation on your lab sheet, as an example. Use correct s.f. and the factor-label method.

3) Compute the mean value of the density by adding up all measurements and dividing by the number of measurements. Report this *result* on the lab sheet.

D = m/V
Density = mass divided by volume
Units: usually g/mL

Practice Calculations

1) The level of water in a graduated cylinder is 52.7 mL. After a solid object weighing 100.0 g is added, the level is 87.4 mL. What is the density of the object?

2) Mercury (Hg) is a liquid at room temperature. The density of Hg is 13.6 g/mL. How many mL are there in 1.00 kg of mercury?

3) Pure ethyl alcohol (CH_3CH_2OH) has a density of 795 g/L. What is the mass of 450 mL of C_2H_5OH?

4) What is the weight (in pounds) of 450 mL of ethyl alcohol if 1 kg = 2.205 lb?

Data and Calculations

Density of a Solid Identity: ____________
Mass (g): ____________
Final Volume (mL): ____________
Initial Volume (mL): ____________
Volume of Solid (mL): ____________
Density of Solid (g/mL): ____________

Show calculation of density:

Density of a Liquid Identity: ____________

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Volume in Cylinder (mL):	_______	_______	_______	_______	_______
Cylinder + Solution (g):	_______	_______	_______	_______	_______
Empty cylinder (g):	_______	_______	_______	_______	_______
Mass of Solution (g):	_______	_______	_______	_______	_______
Density of Sol'n (g/mL):	_______	_______	_______	_______	_______

Show calculation of density for trial 1:

Mean Density: ____________